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Dangerous Confusion in Canada on Water-Quality Guidelines and Criteria for Molybdenum Toxicity

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Summary

There is dangerous confusion in Canada on water-quality guidelines for molybdenum. For the same type of ecosystem, the guidelines differ by up to factors of thousands, which provides little confidence in the safety of water and the prevention of significant toxicity that may appear only in later generations. This dangerous confusion apparently arises from (1) not distinguishing less-sensitive aquatic life with more-sensitive humans, other animals, and vegetation, and (2) the ignorance of direct toxicity testing of humans with various doses of molybdenum. The greatest danger is the application of aquatic-life guidelines at tens to hundreds of mg/L of molybdenum to many other lifeforms whose toxicity limits are significantly less than 1 mg/L. This danger is well supported by technical literature including a public hearing, with sworn testimony, on molybdenum toxicity to humans.

1. Introduction

In this MDAG Case Study, the focus is strictly on natural elements in the Periodic Table. The statements here may not apply to human-made and organic contaminants.

Wikipedia (2026) provides a helpful overview on the meaning of toxicity, touching on its true complexity:

> "Toxicity is the degree to which a chemical substance or a particular mixture of substances can damage an organism. Toxicity can refer to the effect on a whole organism, such as an animal, bacterium, or plant, as well as the effect on a substructure of the organism, such as a cell (cytotoxicity) or an organ such as the liver (hepatotoxicity). Sometimes the word is more or less synonymous with poisoning in everyday usage.
>
> "A central concept of toxicology is that the effects of a toxicant are dose-dependent; even water can lead to water intoxication when taken in too high a dose, whereas for even a very toxic substance such as snake venom there is a dose below which there is no detectable toxic effect. Toxicity is species-specific, making cross-species analysis problematic."

There are many types of toxicity, such as acute toxicity, reproductive toxicity, and neurotoxicity (e.g., Morin, 2025).

One way that toxicity is simplified is through water-quality guidelines and criteria expressed in units such as mg/L, as total (unfiltered) or dissolved (filtered) aqueous concentrations. This simplification is not highly accurate, but provides a relatively simple and approximate way to estimate whether a water sample may be toxic in some way.

Interestingly, the toxicities of some natural elements are so poorly defined that there are no well-established water-quality guidelines for them. As a result, many natural elements are "emerging" contaminants, such as platinum, ruthenium, rhodium, palladium, osmium, and iridium (Morin, 2022).

In Canada, the federal government, through its Canadian Council of Ministers of the Environment (CCME), has created a list of water-quality guidelines designed to be safe for all lifeforms at all life stages. Additionally, some Canadian provinces have created water-quality guidelines differing somewhat from CCME values and/or including potential contaminants not listed by CCME. Some provincial guidelines can be higher than CCME due to the assumption of "extra safety factors" incorporated into CCME values.

These federal and provincial water-quality guidelines are often developed for specific ecosystems like freshwater or marine aquatic life, agriculture (vegetation), ruminant and non-ruminant animals, and subsurface groundwater. Guidelines for drinking water by humans are often developed separately from the other "ecosystems".

2. Dangerous Confusion in Canada on Molybdenum Water-Quality Guidelines

As explained in the Introduction above, there are overlapping federal and provincial water-quality guidelines in Canada. The guidelines for many elements in a specific ecosystem are not identical, but are often close.

Alarmingly, what are the meaning and implications when overlapping guidelines differ by factors of up to thousands of times? Such differences should mean that water-quality guidelines are not reliably estimated and may result in significant toxicity if the higher values are used. Molybdenum is a dramatic example of this in Canada.

Many aqueous elements like copper and zinc in mg/L are relatively more toxic to aquatic life than to humans. Consequently, many people mistakenly believe that water-quality guidelines for aquatic life are always the strictest and safest, and that other lifeforms can tolerate higher concentrations. This is wrong for certain natural elements like molybdenum.

Generally available information on molybdenum explains:

> Molybdenum is an essential trace mineral required for human survival, but it can act as a neurotoxicant at exceptionally high doses, leading to neurological and psychological symptoms... [T]he typical daily intake [for humans] easily meets the body's baseline needs (about 45 mcg/day [0.045 milligram/day] for adults)... [T]he [U.S.] National Academies of Sciences, Engineering, and Medicine has set a Tolerable Upper Intake Level (UL) for adults of 2 mg (2,000 mcg) per day to prevent adverse health effects.

This general information shows that, for example, drinking a single liter of water per day with a molybdenum concentration above 2 mg/L can exceed the human "Tolerable Upper Intake Level (UL) for adults of 2 mg (2,000 mcg) per day to prevent adverse health effects". Consuming additional liters a day of such molybdenum-bearing water, and/or also consuming molybdenum-enriched legumes, nuts, and grains, could result in higher toxicity to an adult human.

Therefore, safe molybdenum water-quality guidelines should be significantly less than ~2 mg/L and should be closer to 0.01 to 0.1 mg/L to allow daily consumption of more than one liter of water and of other sources. This is actually the case in many places in Canada, as shown below. However, some Canadian provinces now contend that ~30 to ~460 mg/L (yes, mg/L) are safe for humans, animals, and vegetation (Ontario MECP, 2026). As shown below, this dangerous confusion apparently arises from (1) not distinguishing less-sensitive aquatic life with more-sensitive humans, other animals, and vegetation, and (2) the ignorance of direct toxicity testing of humans with various molybdenum doses.

3. Examples of Water-Quality Guidelines in Canada for Molybdenum

Table 1 below summarizes the dangerous confusion in Canada on water-quality guidelines for molybdenum. Note that guidelines differ by up to thousands of times for some ecosystems.

Table 1. Selection of water-quality guidelines in Canada for molybdenum

Ecosystem	Jurisdiction	Value (mg/L)
All lifeforms at all life stages, nominally listed as "freshwater aquatic life"	Federal CCME	0.073
All species based on "long-term toxicity data included 11 species... using the CCME Protocol"	Ontario (MECP, 2026)	Short term: 460 Long term: 30.2
Freshwater aquatic life	Saskatchewan (Saskatchewan Environmental Quality Guidelines)	31
	British Columbia	7.6
	Saskatchewan (Saskatchewan Water Security Agency)	0.073
	Ontario	0.04
Human drinking water	British Columbia	0.088
Non-ruminant wildlife	British Columbia	0.284
Ruminant wildlife	British Columbia	0.034
All land uses including agriculture	Saskatchewan	31
Irrigation of forage and non-forage crops to protect "terrestrial vegetation"	British Columbia	0.01-0.03

The toxicity of molybdenum can be complex, such as the failure to breed and the mortality of young appearing only in the third generation of mice (Schroeder and Mitchener, 1971; MEND 2008). Thus, this short MDAG Case Study cannot resolve the problems and discrepancies. Nevertheless, a generally safe level around 0.01-0.09 mg/L appears reasonable to protect humans, other animals, and vegetation.

For protection of humans, a water-quality guideline significantly below 1 mg/L is well established and documented in Canada. A six-day public hearing in Canada was part of an appeal of a treated mine-water discharge into a creek where downstream humans drank the water (MELP, 1998). The sworn testimony included medical doctors and university professors who dosed university students with molybdenum until they showed signs of toxicity. This confirmed that toxicity of humans to molybdenum is significantly below 1 mg/L.

4. Conclusion

There is dangerous confusion in Canada on water-quality guidelines for molybdenum that differ by factors up to thousands. The greatest danger is the application of aquatic-life guidelines at tens to hundreds of mg/L of molybdenum to many other lifeforms whose toxicity limits are significantly less than 1 mg/L. This danger is well supported by technical literature including a public hearing, with sworn testimony, on molybdenum toxicity to humans.

5. References

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